INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT OHIO UNIVERSITY 1990-1991

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SUMMARY OF RESEARCH

This twentieth year of the Joint University Program (JUP) saw continued progress by students, faculty and staff in four major areas. Brief reports are given in this section.

- The study of spectrum-efficient methods for transmitting weather information to aircraft has resulted in definition of an improved amplitude-and-phase modulation process which permits re-utilization of voice channels for both voice and data. The system is being implemented for testing.

- Multi-sensor navigation systems introduce increased flexibility and performance for aviation, at the expense of increased complexity. Insuring a high level of system reliability and integrity requires that faults not only be detected, but also isolated to specific system elements, so that the remaining capabilities of the system may be used with confidence. An algorithm has been developed, and will be tested using combined GPS/INS systems.

- The JUP has served as a vehicle for reporting work accomplished in evoked-potential vision-tracking experiments to determine the engineering parameters of this input and control method. Successful detection of an operator's visual selection of objects has been achieved, and experiments continue to determine resolution and moving-target tracking capabilities.

- Application of GPS in an interferometric mode permits accurate measurement of differential motion; aircraft attitude may be determined using GPS only, with multiple antennas. The JUP team carried out the first known flight tests of this application.

Joint University Program participants are encouraged to report technical results in the open literature. The 1990-1991 papers and presentations are listed in the annotated bibliography on the following pages.

ANNOTATED BIBLIOGRAPHY OF 1990-91 PUBLICATIONS

1. Kline, P. A.: Availability of Positioning and Receiver Autonomous Integrity Monitoring for the Global Positioning System. Proceedings of the 3rd International Satellite Division Meeting of the ION, Colorado Springs, CO, September 1990.

The Minimum Operational Performance Standards (MOPS) are being developed for airborne supplemental navigation equipment using the Global Positioning System (GPS). This is a unique task in the sense that the receiver must provide integrity assurance independent of that supplied by GPS. Independent integrity assurance, or receiver autonomous integrity monitoring (RAIM), requires at least one redundant GPS measurement. Therefore, the availability of GPS depends on the availability of RAIM. A computer simulation is presented for determining RAIM availability for GPS which incorporates a GPS coverage model and a Markov reliability model. The Markov model is used to assign state probabilities to GPS failure scenarios. Up to six simultaneous satellite failures are considered. A parametric analysis is presented to determine the effect on GPS RAIM availability. Some parameters that are included in the analysis are the maximum allowable Horizontal Dilution of Precision (HDOP), the Mean Time To Repair (MTTR) for failed GPS satellites, and the addition or omission of the altimeter as an additional measurement.

2. Farrell, J. L., and Van Graas, F.: That All-Important Interface. Proceedings of the 3rd International Satellite Division Meeting of the ION, Colorado Springs, CO, September 1990.

The goal of nav systems integration should include growth flexibility, to accommodate the future addition of data sources and operations not envisioned in original configurations or plans. That aim is seriously compromised when information available from existent sources is deficient in content, form, timeliness, or precision. Unfortunately this is a common occurrence, not an occasional oversight; information is typically conveyed in ways that became standard long before modernization. Prime examples are attitude (expressed in terms of the familiar roll-pitch-heading convention) and velocity components in single precision.

These and other instances of accepted procedures are reviewed, along with an illustration of how various practices impose fundamental but completely unnecessary limitations on achievable integration performance. In accordance with available means of correcting all deficiencies, which have been widely known for years, straightforward measures are proposed whereby standards can be updated. The related issue of mounting location for critical elements on nonrigid structures is also briefly addressed. In all cases under consideration, the intent is to eliminate impediments to true system integration.

3. Van Graas, F.: In Flight Demonstration of Hybrid GPS/LORAN RAIM. Proceedings of the National Technical Meeting of the ION, Phoenix, AZ, January, 1991.

A receiver autonomous integrity monitoring (RAIM) scheme has been implemented in a real time, prototype hybrid GPS/LORAN receiver. A four-channel GPS receiver and an eight-channel Long Range Navigation (LORAN-C) receiver are used to obtain raw GPS and LORAN pseudorange measurements. The measurement data is sent to a microcomputer for position and integrity determination. Navigation data is presented to the pilot on a standard course deviation indicator with a data renewal rate of up to one update per second. Provisions are made to simulate signal malfunctions in real time by injecting step or ramp failures in the pseudorange measurements. A least squares fault detection algorithm is presented for the detection of slowly growing measurement errors. The performance of the hybrid GPS/LORAN receiver has been demonstrated through actual flight tests. One of the flight tests is summarized in the paper.

4. Braasch, M. S.: A Signal Model For GPS. Published in NAVIGATION: Journal of the Institute of Navigation, Vol. 37, No. 4, Winter 1990-91.

As the development of GPS continues, there will be an increasing need for a software-centered signal model. This model must accurately generate the observed pseudorange that would typically be encountered. The observed pseudorange varies from the true geometric range because of range measurement errors, which stem from a variety of hardware and environmental factors. In this paper, these errors are classified as either deterministic or random, and, where appropriate, their models are summarized. Of particular interest is the model for Selective Availability, which was derived from actual GPS data. The procedure for determination of this model, known as system identification theory, is briefly outlined. The synthesis of these error sources into the final signal model is given, along with simulation results.

5. Van Graas, F., and Braasch, M. S.: GPS Interferometric Attitude and Heading Determination: Flight Test Results. Proceedings of the 47th Annual Meeting of the Institute of Navigation, Williamsburg, VA, June 1991.

Attitude and heading determination using GPS interferometry is a well-understood concept. However, efforts have been concentrated mainly in the development of robust algorithms and applications for low dynamic, rigid platforms (i.e. shipboard). This paper presents results of what is believed by the authors to be the first realtime flight test of a GPS attitude and heading determination system. The system is installed in Ohio University's Douglas DC-3 research aircraft. Signals from four antennas are processed by an Ashtech 3DF 24-channel GPS receiver. Data from the receiver are sent to a microcomputer for storage and further computations. Attitude and heading data are sent to a second computer for display on a software generated artificial horizon. Demonstration of this technique proves its candidacy for augmentation of

aircraft state estimation for flight control and navigation as well as numerous other applications.

6. Van Graas, F., and Farrell, J.: Receiver Autonomous Integrity Monitoring (RAIM): Techniques, Performance and Potential. Proceedings of the 47th Annual Meeting of the Institute of Navigation, Williamsburg, VA, June 1991.

The goal of receiver autonomous integrity monitoring (RAIM) for the Global Positioning System (GPS) is to provide a sufficient level of navigation integrity for all phases of flight based on the signals transmitted by the GPS satellites only. Integrity requirements for airborne use of GPS are reviewed. This is followed by the description of a baseline fault detection algorithm which is shown to be capable of satisfying tentative integrity requirements. The related issue of testing the fault detection algorithm is also briefly addressed. Preliminary performance results for the baseline fault detection algorithm are presented, along with the potential of RAIM techniques for achieving GPS integrity.

7. Skidmore, T.: The Electroencephalographic Human-Computer Interface. Ph.D. Dissertation, Ohio University, Department of Electrical and Computer Engineering, Athens, OH, June 1991.

This dissertation discusses the primary features of an electroencephalographic (EEG) human-computer interface. The paper begins with an overview of the human-computer interface problem and covers issues such as safety, cost, and complexity of technology. A detailed description of the equipment used throughout the research is given. This description includes the electrodes and their placement, the neurodata amplifier, the analog-to-digital converter, the analysis software, and the host computer. The foundation for realizing an electroencephalographic human-computer interface is based primarily on two possible paradigms. The first is a direct thought-controlled interface in which an attempt is made to correlate the EEG data with conscious thoughts of the subjects. Topics discussed in this area include raw-data analysis, chaos theory, autoregressive modelling, biofeedback and asymmetry spectral analysis. The second and most promising method for achieving an interface involves the use of visual evoked potentials. The primary evoked-potential issues presented are verification of the driving response, frequency separation, transient analysis and object multiplicity.